THE USE OF RISK ASSESSMENT, RISK MANAGEMENT AND RELATED MEASURES TO COMBAT THE OCCURRENCE OF EXPLOSIONS IN COAL MINES.

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SUMMARY

Considering the potential consequences of coal mine explosions, the reaction that follows in the wake of such an incident is understandable. To reduce the potential for such explosions and other mining accidents, the use of Risk Assessment and Management has been incorporated in the new Health and Safety Bill (1996) in South Africa. However, even though such systems have been implemented with success in other parts of the world, explosions and accidents do still occur.

This paper presents the rationale for work that is presently being conducted into reducing the explosion hazard with particular reference to risk assessment techniques, as well as other processes to enhance the output from these recognised techniques. The enhancements will include a process that would increase the ability of workers to recognize the potential for an explosion using change as a hazard indicator.

It is anticipated that this system will close any possible gaps in a newly introduced risk assessment system, and ultimately contribute to the successful implementation of Risk Management as a valuable weapon in the fight against the explosion hazard.

INTRODUCTION

Throughout the world considerable resources have been, and are still being spent on reducing the potential for explosions in coal mines. Explosions in coal mines understandably always elicit a serious reaction from both the public and legislators, and are usually followed by in depth investigations not only to determine culpability for the event, but more importantly to determine what occurred to assist in preventing further such incidences.

Various safety methods have been used throughout the years to identify the problems leading to explosions and solutions proposed to either prevent them from occurring or to mitigate the effects of explosions.

Whereas Risk Assessment and Risk Management have been used in recent decades in industries outside of the mining industry, such as the nuclear industry, it has recently been utilized more and more in the mining industry. With the introduction of the new Health and Safety Bill in South Africa, the use of Risk Management will become a legislated and integral part of mining activities. In this newly promulgated Bill, it is specified that every manager must identify hazard and assess risks to which employees may be exposed while they are at work. Further, the manager must ensure that not only are these hazards and risks recorded, but, after consultation with the Health and Safety Committee at the mine, determine and implement measures to eliminate, minimize, contain at source or, where risks remain, to provide for protection of workers and monitoring of the risk. The Bill thus requires a Risk Assessment and Risk Management programme to be instituted.

The present status of introducing and implementing Risk Assessment and Risk Management in the South African mining industry can be characterized by the following:

- New and not well understood
- Seen to be not different from previous practices
- Legislated with the onus of proof that it has been professionally implemented resting with mine management
- Fear by management of the implications
- Benefits not appreciated.

RISK ASSESSMENT AND RISK MANAGEMENT

Risk can formally be defined as the possibility of an injury, loss or damage occurring and Risk Management are those actions that are taken to prevent it. MineRisk, a system that has been extensively applied in the Australian mining industry, is, following a licence agreement with the CSIR : Mining Technology, now available in South Africa.

The specific approach used by MineRisk and CSIR : Mining Technology addresses the problems of Risk as follows:

- Risk is a combination of the consequences of an event and the probability that it will occur.
- The consequences may entail losses or injuries to people, assets, production, etc.
- A loss is due to an unwanted release of energy
- Release of energy is controlled by various types of barriers.
- Barriers are developed and implemented in work processes by management systems.
- It can therefore be deduced that all accidents are a result of failures in the management system.

Of special interest in this formulation is the use of a release-of-energy principle and the philosophy that accidents are caused by a failure in the management systems. The release of unwanted energy is controlled by the barriers established by the management system which in turn consist of standard operating practices, competency of the people, fitness of the equipment and control of the work environment. Control of the environment covers:

- Setting of standards
- Measurement
- Evaluation of the results
- Rectification in the event of a deviance from standard (within certain limits.)

The process of Risk Management, proposed by MineRisk, consists of four steps: are the identification of hazards; assessment of their severity, i.e. the consequences of the hazard, and probability of it occurring; devising processes and measures to control these hazards; and the implementation and maintenance of these control measures. In the event of the monitoring indicating inefficiencies in the procedures, the entire process is revisited to address the identified problems.

As the entire process is team-based, significant other benefits, apart from process output, are also achieved. By informing all the parties of both the problems and solutions, the procedures are not only supported by all parties, but an increased awareness of cause and effect, as well as a better understanding of the hazards, are also obtained. Notwithstanding these benefits, the fact remains that, even when such systems are installed and maintained to high, professional standards, accidents still occur.

The process is presented graphically in Figure 1.

A possible reason for this is an inadequacy in the identification of hazards which is carried out beforehand, and is based on the accumulated knowledge and experience of the team. Even with a team of knowledgeable people, there is the potential for unknown hazards and their causative factors not to be identified. This, in turn, infers that proposed procedures could possibly not provide for all circumstances that could occur.

It is for this very reason that the process itself makes provision for a monitoring aspect to ensure continual updating and improvement. Unfortunately an unidentified and unprovided for hazard could lead to an event or accident before the system had time to erect the required barriers.

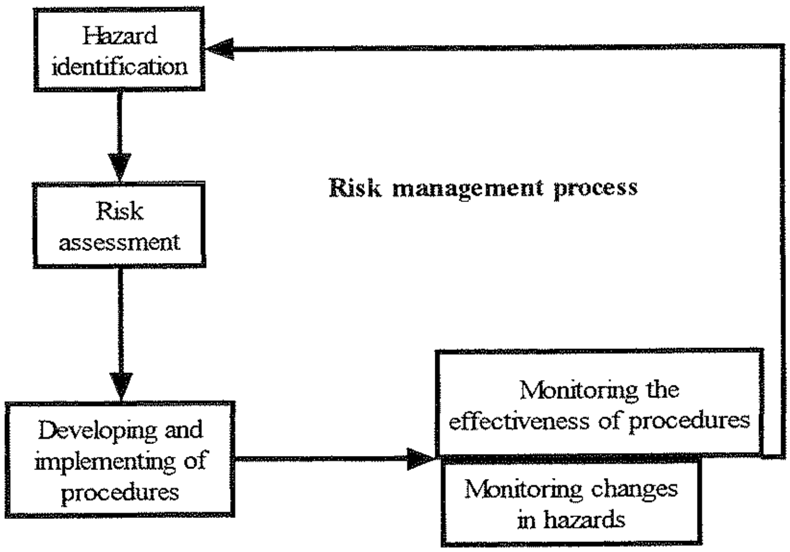


Figure 1: Diagram illustrating the risk management process.

SYSTEM FAILURE IN THE CASE OF UNDERGROUND EXPLOSIONS

It has been stated, and it is generally accepted, that the cause of accidents is the failure of the installed system. If the system could not erect the barriers to prevent the event occurring, it failed in its objective as it was inappropriate for the tasks required from it. If it can be assumed that responsible management ensures that the management system is adequate to the best of their knowledge or resources available, then why was the system inadequate?

An indadequate system means that not all possibilities were identified or there were insufficient funds to cope with the risk. Assuming that, due to the serious consequences of explosions, it is doubtful that management would save on resources, this then indicates that not all possibilities were identified. Considering this in depth, for the system to have failed, a change must have occurred, either a change in the severity of the impact, a change in the nature of the impacts or a change in the way the system reacts to the presented impact.

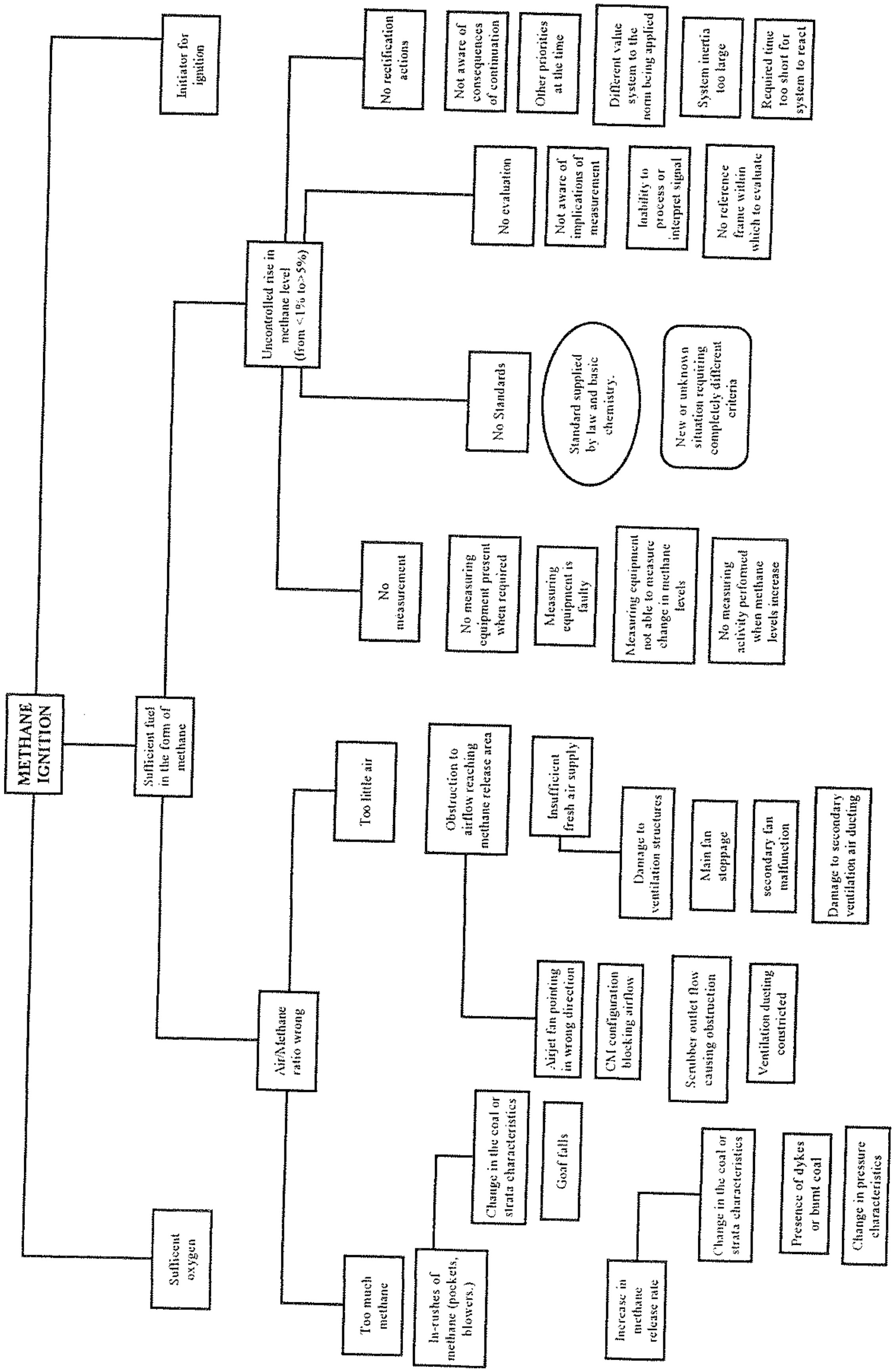
To enable the system to cope with a change, it should have sufficient stored energy in excess to what is normally required. This is the safety factor built into the system to cope with the pre-identified hazardous impacts. As energy is a function of power and the time over which it is exerted, the speed at which the changes and resultant impact occurs is of great importance. The shorter the time interval, the greater the effort that will be required to effect ratification. The greater the speed of change, the greater the size of the hazard.

By using a derivation of causative effects (Figure 2), the effects of change in the occurrence of an underground explosion can be investigated.

For an explosion to occur in a colliery three fundamental ingredients have to be present:

- initiating source;
- oxygen; and
- fuel.

It has been indicated that, in South Africa, the greatest risk of ignition is frictional ignition caused by continuous miners cutting into hard materials in the cutting horizon. The frictional heating of the cutting pick is the source required for the explosion. If there is methane present then the fuel is present and, unless some form of inertisation around the cutting head is being used, there is always sufficient oxygen. All the constituents for an explosion are then present.


METHANE IGNITION
Initiator for ignition
Sufficient fuel in the form of methane
Sufficient oxygen
Uncontrolled rise in methane level (from <1% to>5%)
No rectification actions
Not aware of consequences of continuation
Other priorities at the time
Different value system to the norm being applied
System inertia too large
Required time too short for system to react
No evaluation
Not aware of implications of measurement
Inability to process or interpret signal
No reference frame within which to evaluate
No Standards
Standard supplied by law and basic chemistry.
New or unknown situation requiring completely different criteria
No measurement
No measuring equipment present when required
Measuring equipment is faulty
Measuring equipment not able to measure change in methane levels
No measuring activity performed when methane levels increase
Air/Methane ratio wrong
Too little air
Obstruction to airflow reaching methane release area
Insufficient fresh air supply
Damage to ventilation structures
Main fan stoppage
secondary fan malfunction
Damage to secondary ventilation air ducting
Airjet fan pointing in wrong direction
CM configuration blocking airflow
Scrubber outlet flow causing obstruction
Ventilation ducting constricted
Too much methane
In-rushes of methane (pockets, blowers.)
Change in the coal or strata characteristics
Goaf falls
Increase in methane release rate
Change in the coal or strata characteristics
Presence of dykes or burnt coal
Change in pressure characteristics

In investigating a solution, attention has been directed at reducing the fuel rather than at reducing the initiation potential or the presence of oxygen. This was because it was anticipated that the greatest contribution could be made in this area over the shorter term.

For sufficient methane to be available to fuel an explosion, there must be a change in the ratio of air to methane release and in the way the methane rise was controlled. For the methane/air mixture to have changed, changes must have occurred in either the rate at which the methane was released or the rate at which fresh air has been supplied to the section. Generally, it can be anticipated that the characteristics of South African coals do not change dramatically over the shorter horizontal distance and therefore there should not be a significant change in the methane content and the release rate of the coal. (If burnt coal is encountered, however, then methane levels can rise dramatically.) What is more common is a reduction in the airflow supply. Obstructions in the airflow path, main and secondary fan malfunctions will all cause a rapid change in the air supply and require quick action to maintain control. In most cases problems with ventilation are so serious that the system cannot cope normally and operations have to be curtailed until the ventilation is back to normal and any build-up in methane has been cleared.

For the methane levels to rise from 1 %, when alarms should be sounded, to above 5 % when an explosion can occur, means that no control was exercised. No measurement of the levels could have taken place or, if it had, the values could not have been evaluated. Standards for such evaluation always exist in the case of methane, however, as they are determined by the rules of chemistry or by mining regulations.

The human factor plays a significantly more important role in the changes that occur. When no measurement is taken it would either be because the activity was not performed or the equipment was malfunctioning due to it not being maintained to the required level. The possibility does exist that such levels could rise at a rate faster than the response time of the installed monitoring equipment; however this probability is very low. If measurements were taken and no evaluation carried out, then the system, which includes the workers, were unable to do so. Either the workers were unaware of the implications of the increased levels of methane, or they lacked the ability to interpret the signals indicating the rapid rise. This would be due either to a lack of knowledge or the lack of an adequate reference frame against which they could adjudicate the changes that were occurring.

Assuming there was measurement and evaluation, unless rectification action is taken in the process of control, these acts are worthless. In considering why no action was taken, two main reasons are apparent. The system could not react fast enough to allow rectification. This could either be due to the inertia of the total system or the rate at which the changes occurred. Or, the lack of action could be due to the human aspect of the system. At the time of change the workers were not aware of the consequences of not taking action, they could have had different priorities at the time or their value systems did not apply to the situation.

As the system is unable to cope, a method of timeously warning management of an uncontrollable event will have to be devised. Using the fact that a change is occurring as the indicator, while the event may not always be prevented, serious losses can be minimized by warning management of the changes that are occurring.

The process of risk management then becomes one of managing changes, a principle that can be used to devise solutions that are required by the mining industry.

SOLUTION DEVELOPMENT

In proposing a solution, cognizance is taken of the following aspects:

- The hazard identification process could not have identified all the possibilities
- The procedures do not cater for all possible impacts
- The monitoring process might not effect the required changes in the time period available.

It can be anticipated that these shortcomings will be more prevalent in the initial phase of the introduction of Risk Assessment than at a later stage when the process is well known by the mining industry.

It is not intended to replace the presently used Risk Assessment and Management processes as these have been proven to result in major improvement. What is, however, suggested is to augment the processes that are presently being introduced with a process that could diminish the shortcomings and make a contribution without incurring significant additional expenditure.

It is proposed that a parallel process to the identification of hazards is instituted to increase the awareness of workers of the importance of checking for changes in their environment as these will indicate a risk. This requires not only looking for significant changes, but also becoming sensitised to smaller changes. These changes could occur in the way colleagues act and work. The worker should also be aware of the fact that the greater the rate of change, the greater the risk of a hazard occurring, and they need to act with commensurate speed to alert management to such occurrences, even though they might not always be aware of the full implications of the change.

In Figure 3 the Risk Assessment and Management procedure is shown with the addition of the proposed system.

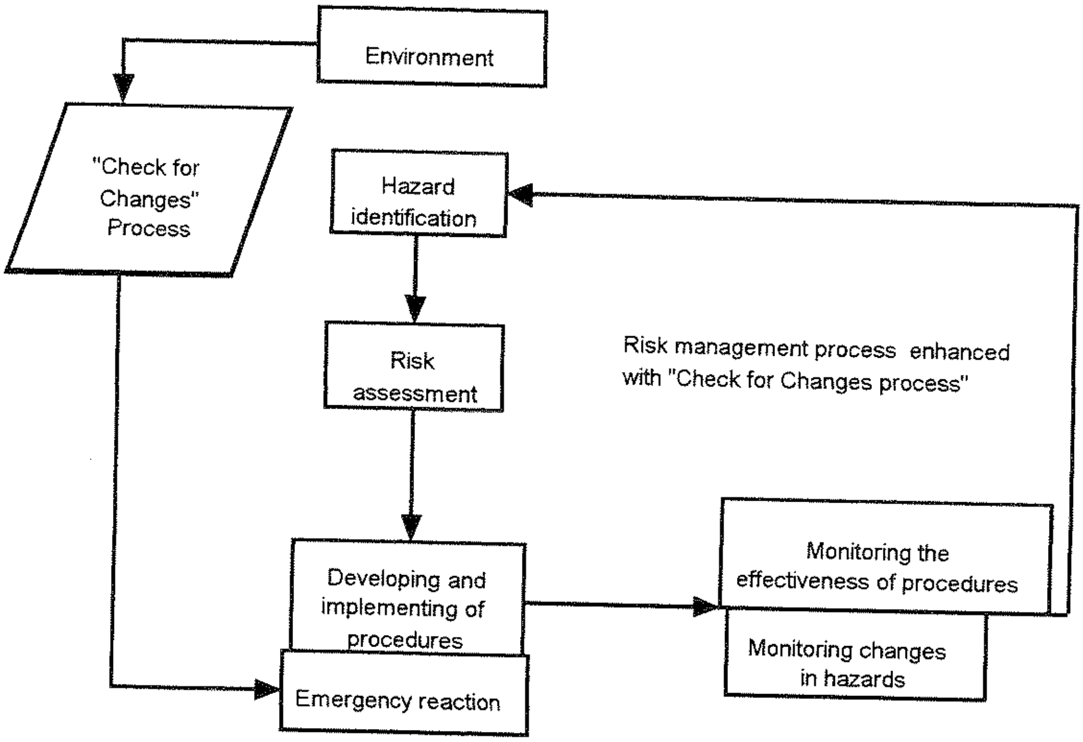


Figure 3: Risk Management process enhanced by the addition of the "check for changes" process.

In the event of a change being noticed, the process will immediately alert management or supervision to its presence.

If the change is so great that a significant hazard is indicated, then operations can be stopped until the situation is under control. This emergency type of response will become part of the procedures. Thus, the routine process will, in addition to monitoring the events and identifying if the procedure were sufficient, also monitor whether a change in the identified hazards had occurred. This information will be fed back to bring the system up to date.

As the human being is constrained in his ability to detect changes, especially if they occur over a longer time period, an electronic control system is also proposed to alert mine management and section workers to impending hazards with the least delay. This system should be able to identify changes in the section environment as well as detect changes occurring in the outside environment that could have an impact on the safe operation of the section. It is envisaged that such a system could be established using and interpreting information that is presently available on mines. As the system evolves, additional sensors can be developed and installed to make the system more sensitive to smaller changes.

CSIR : Mining Technology has embarked on a project to establish the hard- and software required for such a computer based system to determine the potential for explosions occurring in a coal mine.

CONCLUSIONS

The reason for accidents occurring, even when established Risk Management processes are used on a mine, can be found in the inability of the installed systems to cope with the changes occurring. The greater the rate at which these changes occur, the greater the hazard.

The management of risk through the management of change should not be restricted to physical aspects but should incorporate the human factor as a major part.

By augmenting the management system with procedures that include both the training of workers and the utilization of electronic control processes, a significant further contribution to a safer workplace environment can be achieved.